STRUCTURAL TRANSFORMATIONS (BAU 6)
(BAU - BASIC ARCHITECTURAL UNIT)

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Introduction

While the teaching of the phenomenon of form as well as space is normally seen within an environment of free experimentation and personal expression, other directions prove to he worth of pursuit. The proposed paper represents such an exploration.

The generation of controlled complexity and structural transformations have been the title of the project which forms the base of this paper. In it, the potential for creative development of the student was explored in such a way, that as in the sciences a process can be reproduced or an exploration utilized in further experimentation.

The cube as a well proven B.A.U. or basic architectural unit has again been used in our work. Even a simple object like a cube has many properties. As properties are never pure, but always related to other properties, and looking at a single property as a specific value of a variable, it is possible to link a whole field of objects. These links provide a network of paths through which exploration and development is possible.
The paper represents a first step in a direction which we think will compliment the already established basic design program.

General Context

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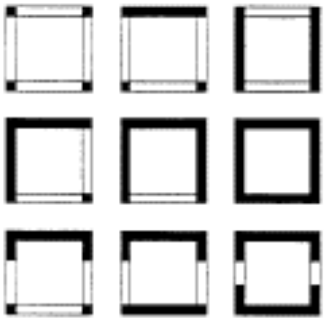
There is a very general context to which I can relate what I am describing here: An object with its relationship to man, to the natural and cultural environment. Thus I am only dealing with a rather small problem out of a vast context. And even the abstraction of the architectural object to a cube or at least to a cluster of cubes will be maintained, mainly dealing with certain properties of such an object.

Basic Design Context



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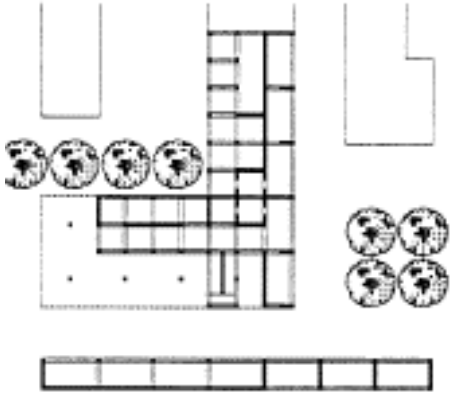

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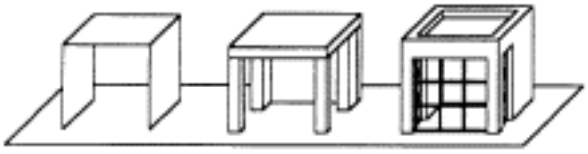
Within the sequence of exercises in the structured program for teaching basic design and construction in the group of Prof. H. Kramel, there is a step in which nine basic space defining units are used as a media to lead in plan from a functional layout to a floor plan and in space from a volumetric layout to a differentiated spacial structure. We call the plan and the model representing this intermediate stage structural plan and structural model respectively.



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The Model preceding the structural model is a volumetric model and the following one a detailed model. That is, we try to develop models with increasing resolution over basically three steps.

CAAD Context

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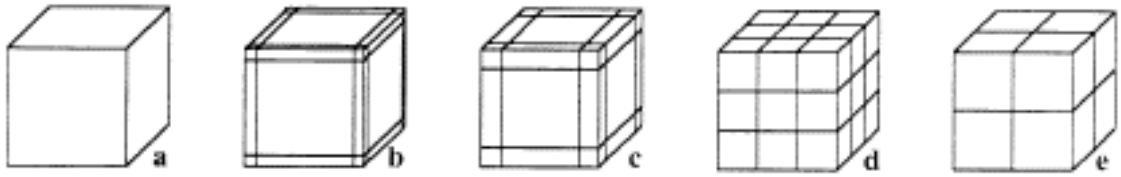
During the last few years about a fourth of our students have used Macintosh computers to do their exercises, and we use mainly ArchiCAD as a CAD software.
In making the preparations for the students I had to think about how to combine best the possibilities of the software with the aims of the exercises. In the above mentioned exercise with the space defining elements I prepared nine library elements with their respective 2D and 3D descriptions. So the students could generate the model quite easily, thus concentrating on the design aspect of the exercise. But the manipulation was basically limited to moving, adding, removing and replacing units. To increase or decrease the resolution, a whole new model had to be built.
So I wanted to see if it was possible to go further. The 3D description of an ArchiCAD object can be parameterised, meaning certain properties of an object can he described. Changing values of parameters will then change the properties. So the properties not only exist outside the object but also within it, and specific operations can he performed on it. In a certain way the object contains some knowledge about itself.
Knowing that there are more suitable CAD environments for such a pursuit and being aware that others have done work in this direction, I tried to do something focussed on our basic design course within the limits of the software the students use too.

Structural Transformations

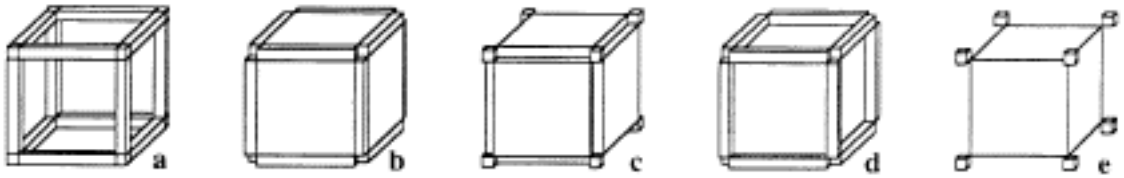
Architects and designers have for a long time been fascinated by the cube and its properties, and I share this interest too. In 1970 Jan Slothouber and William Graatsma published "cubics, cubic construction compendium" which is like a bible on the cube. The nowadays easier access to computers opens new possibilities worth taking up the interest again.
Three objects with various parameters defined in the language GDL which is integrated into ArchiCAD are used in this section: a single cube, a cube represented by twelve sticks (edge-cube) and a cube defined by six slabs (face-cube).

I. Cube - Materialisation **6**



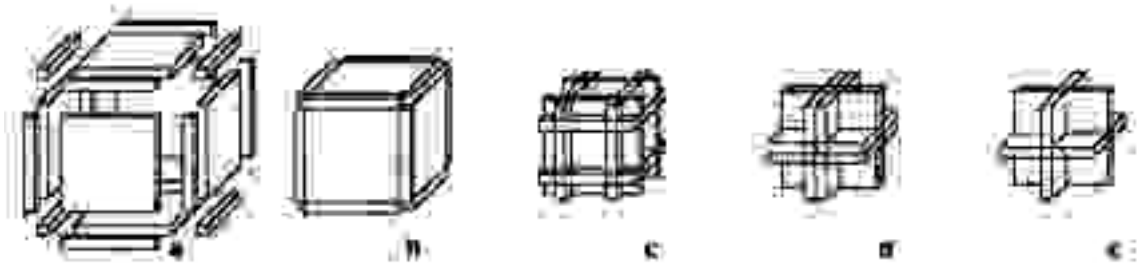
Nodes, edges and faces of the cube which are initially abstract definitions get a material thickness of varying value. Through the change of one property also other properties are affected. The two last examples are especially interesting. In 6.d nodes, edges, faces and the volume of the cube are represented by a cube of identical size. In 6.e the cubes volume becomes a node, the nodes volumes and the edges planes.

II. Cube - Subsets **7**



Based on the cube 6.b. Some obvious subsets of parts of the cube. This property is not linear. The possible values are determined by combination theory.

III. Cube - Implosion and Explosion **8**

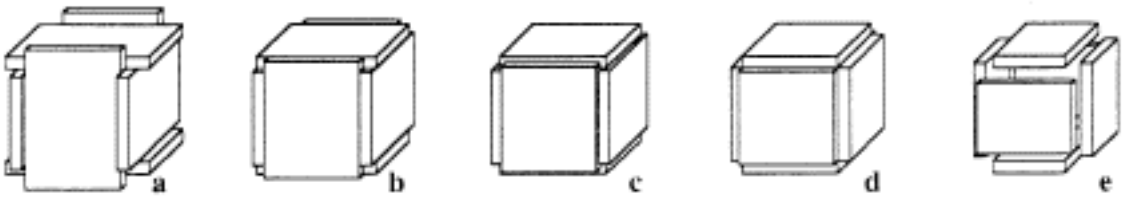


Based on cube 7.b. An explosion factor is applied. The implosion (negative values) is more interesting, as the interpenetration of the elements create new properties or specific configurations: The relationship between the elements changes with certain values of the explosion factor.

IV. Edge-Cube -Thickness **9**

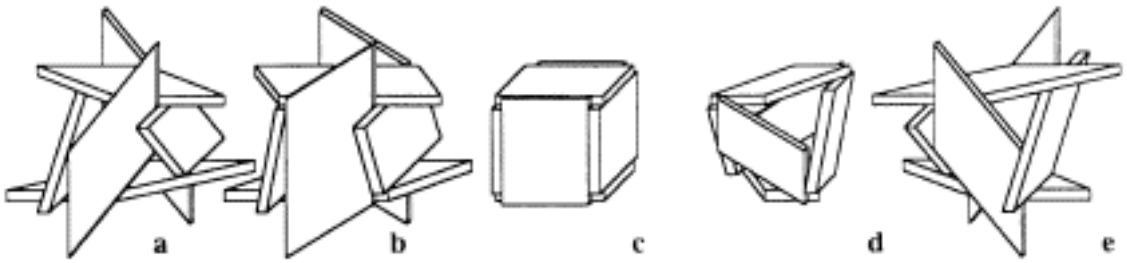
Although only the proportions of the originally square section of the sticks defining the edges are changed, resulting configurations are quite different from each other. 9.a represents the cube as a box, where 9.e represents the cube as a node, both being built up by elements of the same size which are no more sticks but boards.

V. Face-Cube - Slablength **10**



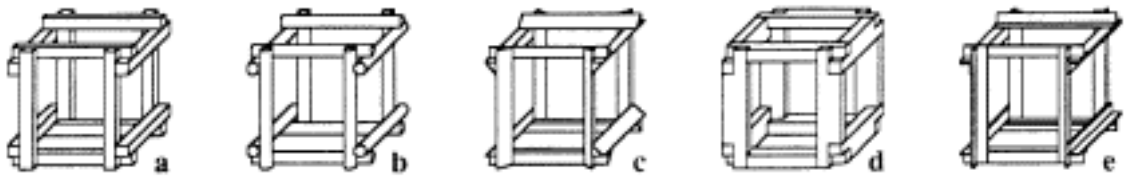
Changing the length of the slab also changes the relationship between the slabs at the nodes and the edges. Certain changes only lead to proportional differences where others result in specific configurations.

VI. Face-Cube - Deformation of Elements **11**



Here the deformation consists of a translation of the corners of the slab in one or two directions. Again the simple change in a value of a property leads to quite surprising results.

VII. Edge-Cube - Replacement of Elements **12**



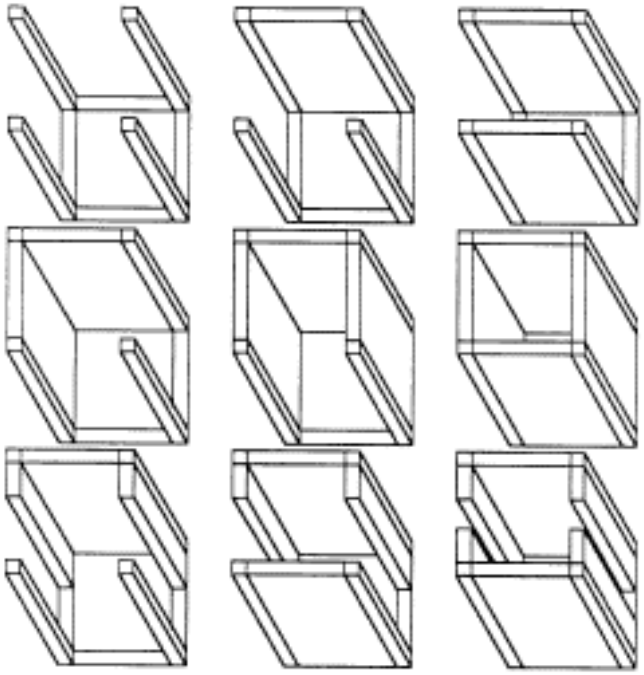
Here the property consists of the type of element the edge is represented by.

I only showed a few sequences or sets of cubes where a single property has been applied. Of course more properties can be defined and several properties can be changed to produce a much wider variety of instances of the cube. But not the variety as such is of main interest, but the fact that new qualities appear through changes of values of defined proper-ties, and that quite different configurations are linked to each other.

Nine Spacedefining Units

In a second step I tried to find a link between purely geometrical transformations to transformations which are also relevant to architectural structures. I defined another object with a number of parameters in a way that it can represent architectural space and even a certain materialisation and construction. It is applied to the before mentioned exercise using nine spacedefining units. Each unit is an instance of the same object. The type of spacedefinition is determined by the value of a parameter. The main parameters of this object are illustrated on the following two pages.

The model can be built up as a volumetric model first. Than each unit can be set to its spacedefining type. Further differentiations can be applied to the complete model. The possibility of applying changes to the whole model without having to rebuild it allows to explore its properties and to study the architectural qualities which change with different values for parameters. Later the model can still be worked out more in detail with additional elements.



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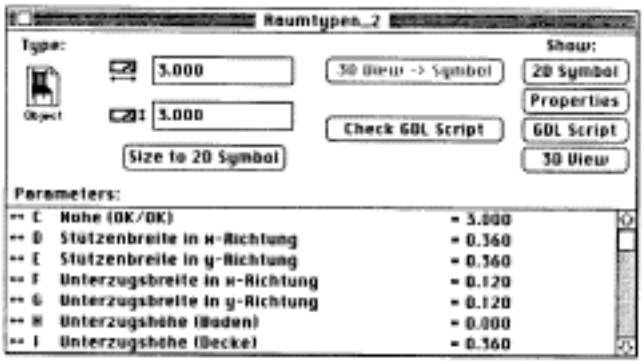
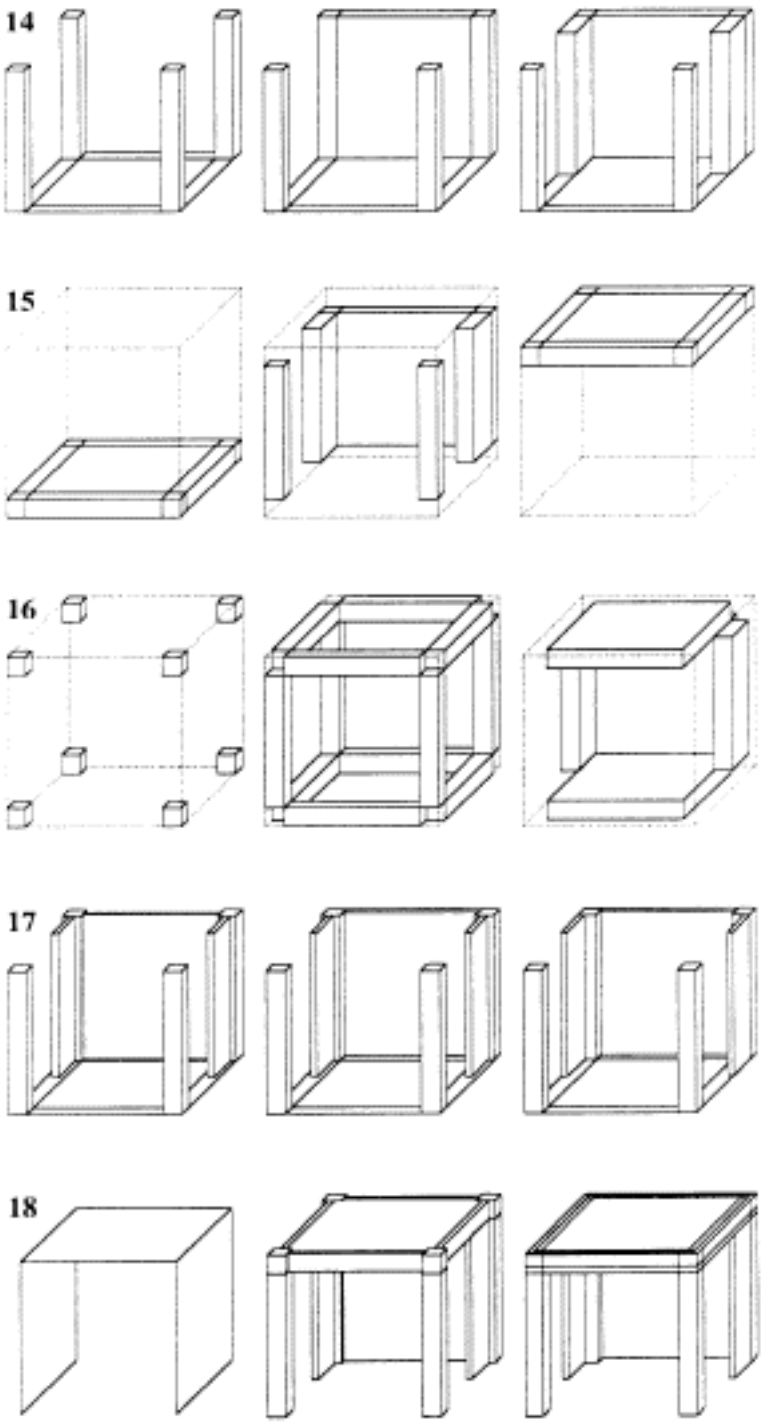


Type Parameters

Some parameters determine a type. That is the value of the parameter selects one of a set of given alternatives. Practically this is not elegantly solved, as numbers not really indicate the choices. A graphical picker would be more useful for this kind of parameter. The relevant types are: spacedefinition, spacial layer, construction type, visibility and edge condition. The following illustrations show three examples of different values for each parameter.



Type of Spacedefinition.
The minimal definition spans a space within four posts. Full and partial walls in various positions increase and specify the spacedefinition.

Space Layer.
All the combinations of the three space layers (floor, space and ceiling). They help in building a multistory structure, or filtering partial information.

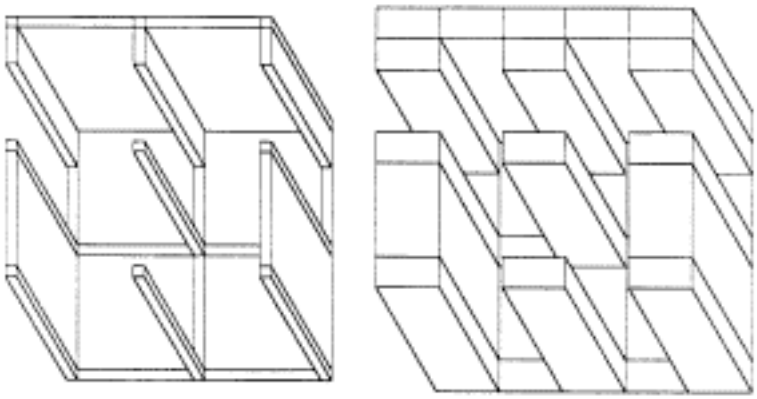
Visibility.
Nodes, edges, faces and volume or their combinations can be shown, or hidden. This also helps to display only certain aspects of the model.

Edge-condition.
Offcentered walls and certain beamtypes have different conditions when they are located between units or at the edge of an unit.

Type of Construction.
At present only three types of construction are implemented, which correspond to modelresolutions used in the basic design exercises.

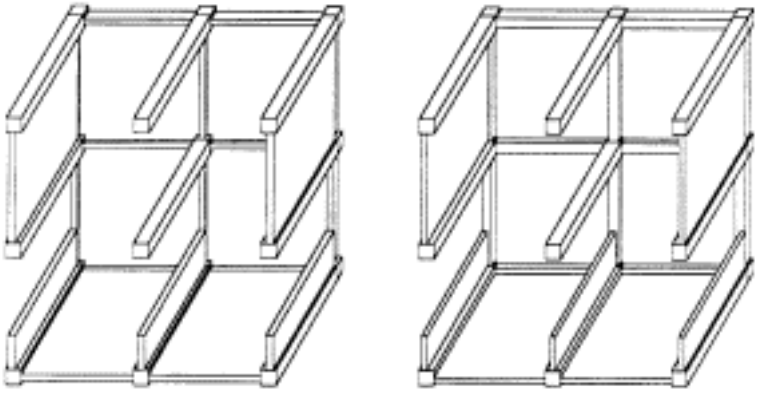
Measure Parameters

The parameters representing variable measurements are chosen so as to enable geometrical exploration as well as making sense on a construction level. Posts are distinguished from beams, walls from floor and ceiling etc. The distinction of measurements in x- and y-directions is more for the geometrical level. ArchiCAD limits the number of parameters to 26, what already for this quite simple object is restricting. In the illustrations a configuration of four units is shown.



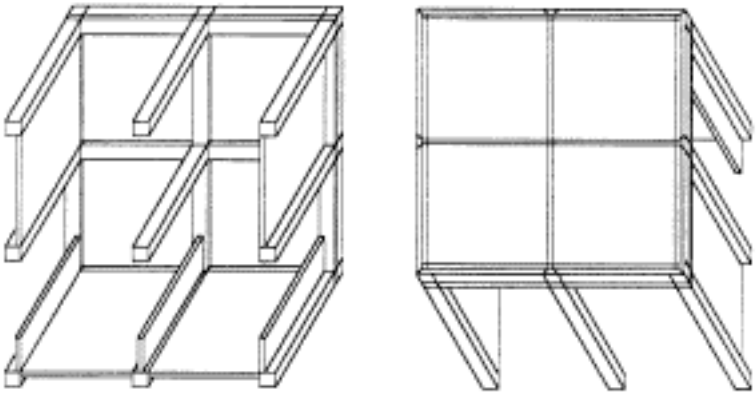
Distinction of x- and y-directions.
For the structural and spacial exploration of a configuration it is interesting to distinguish the two) directions.
Geometrical model.

19



Relationships.
Differentiating measurements of posts, beams and walls lets explore architectural expressions of a configuration.
Geometrical model.

20



Wallposition.
The position of the walls relative to posts and beams has also an influence on the architectural expression.
Model with inverted T-beams.

21

Final Remark

When drawing with a pen on paper, with only a few strokes it is possible to produce something that is more complex than pen and paper are as tools. This becomes different using a computer. The tool has reached a complexity which is not easily reached when using it. The relationship between the complexity of the tool and the work done with it is not given, it has to be established. The tool is only giving opportunities, the effort has to be made by the user. So the challenge has to come from the design side.

References

Jan Slothouber and William Graatsma. 1970. Cubics, a Cubic Construction Compendium. Deventer, Octopus Foundation.

Lionel March and Philip Steadman. 1971. The Geometry of Environment. London, RIBA Publications Limited.

SergeChermayeff and Christopher Alexander. 1966. Community and Privacy. Harmondsworth, Penguin Books Ltd. (Steinberg cartoon).